

### Remarks

Claims 15, 16, 18, 25, 33 and 34 are pending in the application. All claims had heretofore been finally rejected as having been obvious to one of ordinary skill in the art over the paper to Dai et al., taken in view of Helmer-Metzman et al., Hodgdon et al., and Larminie, et al. in respect of Claims 33 and 34. It is respectfully submitted that the rejections, especially if applied to the claims as currently amended, are in error.

While acknowledging in paragraph 4. of the June 3, 2009 Office Action that the polymer of the Dai et al. reference contains an additional sulfone phthalazinone structural unit, the Examiner asserts that “it still reads on the polymer of structural formula I in claim 15,” observing that “There is no claim language or features of structural formula I that excludes other monomer units.” The same point is made in the Examiner’s **Response to Arguments** (paragraph 16 of the Action).

### *Amendment of the Claims*

Irrespective of any merit that the Examiner’s assertions might have had, the amendments to the claims now presented render them moot. Each independent claim of the application (Claims 15, 16, 18, 33 and 34), as amended, defines the sulfonated poly(phthalazinones) [or poly(phthalazinone), as the case might be] as consisting essentially of the units of structural formula I, defined in Claim 15. Thus, and contrary to the assertion made by the Examiner, all of Applicants’ amended claims do contain language that excludes monomer units other than the sulfonated poly(phthalazinones) defined and, more particularly, that exclude the sulfone phthalazinone structural unit that is a fundamental and essential element

of the Dai et al. PPESK copolymers, which must include both diphenylsulfone and also diphenylketone units.

Obviously, the Examiner has, throughout the course of prosecution of the instant application, carefully considered the novelty and nonobviousness of sulfonated poly(phthalazinone) homopolymers, vis-à-vis prior art (Dai et al.) that teaches copolymers. The amendment to the present claims could therefore hardly be considered to raise any new issue, since the Examiner himself presented it previously.

It is equally obvious that the Examiner's search would have uncovered any reference that might be pertinent to sulfonated poly(phthalazinone) compositions, be they homopolymers or copolymers. Since the Dai et al. copolymer is deemed by the Examiner to be pertinent to the invention, as originally claimed, a reference teaching or suggesting a sulfonated poly(phthalazinone) homopolymer would certainly have been deemed that much more pertinent.

It seems self evident that the present amendments place all claims of the application into condition for allowance.

#### *Additional Reasons for Allowance*

Albeit the forgoing remarks alone should remove any doubt as to the patentability of Applicants' invention, the following further observations are made to emphasize that the differences in the polymers is not merely academic, and to address other issues which, in and of themselves, establish the novelty and nonobviousness of the claimed invention.

Firstly, as presently amended all independent claims of the application recite a degree of sulfonation in the range of 0.6 to 1.0. The Examiner asserts that the polymers of Dai et al., have a degree of sulfonation (DS) of 200%, and that this "appears to correspond to a DS of 1

according to the present Claim 15.” This assertion appears to be based on the Examiner’s belief that, when there is one sulfonic acid group per repeat unit of the polymer, the DS is 1.

It is apparent from the structural formula for the reference SPPEK’s that there are two sulfonic acid groups per repeat unit of the polymer. However, it is acknowledged that, since the Dai et al. structure includes two types of phthalazinone repeat units (sulfone and ketone), each with its own SO<sub>3</sub>H groups, it has a DS value of 1.

But nevertheless, Applicants’ claimed structure is clearly different and patently distinct from that of the reference. This is emphasized by the fact that in *Applicants’* polymers the claimed DS range imparts unexpected and highly desirable properties. The same degree of sulfonation in Applicants’ sulfonated poly-phthalazinone ether ketones (SPPEKs) results in properties that are different from, and superior to, the properties of the sulfonated polyphthalazine ether sulfone ketones (SPPEKs) of Dai et al.

The Examiner’s attention is directed to Figures 6 and 7 of the specification, which show that conductivity is notably different in the two classes of compounds. More particularly, Figure 6 shows the conductivity of SPPEKs of various DS values, according to Applicants’ invention, and Figure 7 shows the conductivity of prior art SPPEKs at a DS of 1.0. When the latter is compared to Figure 6, for a DS of 1.0, it is seen that significantly higher conductivity is observed for the SPPEKs of the invention.<sup>1</sup>

Specifically, the maximum conductivity of DS 1 SPPEK is seen in Figure 6 to occur at about 90°C., and conductivity is ~ 4 x 10E-2 S/cm. Comparing this with DS 1 SPPEK at

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<sup>1</sup> The last two values in the scale at the bottom of Figure 6 should obviously be 100 and 120. It is evident that the values increase from zero in 20° intervals, making the upper limits of the two sections, beyond 80°, 100° and 120°. Consistent therewith, the discussion of Figure 6 under the heading “Proton Conductivity,” on page 16 of the specification, includes the statement “As can be seen, the conductivities of these two SPPEKs increase with increasing temperature up to 95°C ...”. A replacement sheet correcting Figure 6 accompanies the present Amendment.

the same temperature, in Figure 7, conductivity is  $\sim 2 \times 10^{-2}$  (i.e., half the value), and DS 1 SPPEK is  $\sim 1.5 \times 10^{-2}$  S/cm (lower still). This difference in conductivity is also notable at 80° C. Taken in proper context, therefore, the Examiner's assertion in paragraph 17 of the June 3, 2009 Office Action, that Figure 7 is not relevant, is seen to be clearly incorrect.

Secondly, the claimed compounds having DS values of 0.6 to 1.0 are insoluble in water (at least at temperatures up to 80° C.), as established by the data in Table 5 of the specification. In contrast, the SPPEKs of the reference which have a DS in the range of 150 to 200+% (as evidenced by Tables I and IV on pages 1686, 1690) are water-soluble at DS somewhere between 150% (HSPPEK) and 200+% (SHSPPEK). Water solubility at operating temperatures is of course fundamental to the ability of a polymer to function as a membrane in a PEM. The instant SPPEKs are eminently suitable for that application, as discussed on page 14 of the specification and emphasized in Claims 33 and 34; nothing taught by Dai et al., on the other hand (or in other prior art), would have anticipated or predicted this distinguishing property of the instant materials.

The Examiner's contention that the polymer of Dai et al. "reads on the polymer of structural formula I in Claim 15," is also clearly incorrect, and that is so for reasons that go well beyond the fundamental distinction (exclusion of copolymers) discussed above.

Firstly, the portion of the Dai et al. structure that compares to the claimed structural formula I has only a *single* sulfonic acid group. The instant compound necessarily contains *two* such groups.

Moreover, in paragraph 6. of the June 3<sup>rd</sup> Action the Examiner points to the disclosure in the Dai et al. reference at page 1688, left column, beginning "Predictions [for the location of  $-\text{SO}_3\text{H}$ ] run on both S and K type units show that the next [most likely] upfield proton [for

sulfonation] is H14/H15 of the K unit.” This site is of course the site of the second sulfonation in the presently claimed compounds.

In the disclosure bridging the bottom of the left column and the top of the right column of Dai et al., furthermore, it is stated that when the DS is greater than 200% “the site of sulfonation may occur at H14/H15(K only).” The Examiner then equates a DS of greater than 200% to a DS of greater than 1. Apparently, the Examiner construes this disclosure to show the compounds of structural formula I; i.e., including sulfonation at both H1/H4 and H14/H15 positions. It is submitted however that this disclosure clearly relates to *optional* sites for sulfonation, depending upon the DS, and it is emphasized that the disclosure clearly states “(K only)”; i.e., for DS values greater than 200% the sulfonation can be in the K unit at position H14/H15, not both H1/H4 and H14/H15. In addition, the reference nowhere discloses more than one sulfonation in the K unit.

#### *Process Claims*

The Examiner’s position with respect to process Claim 18 was stated in paragraphs 3, 5 and 7 of the June 3<sup>rd</sup> Action. In paragraph 3. he asserted that Dai et al. disclose, at page 1686, the use as sulfonating agent of 98% concentrated sulfuric acid or 20-25% fuming sulfuric acid (Oleum) [see also Table 1]. In fact, these are the only two sulfonating agents used in the reference.

There is absolutely no teaching or suggestion in the reference of or for the use of mixtures of concentrated sulfuric acid and fuming sulfuric acid, let alone the use of a specific range of ratios to provide the claimed DS range of 0.6 to 1.0. The Examiner appears to recognize this in paragraph 7. of the Action, but then states that Dai et al. discloses sulfo-

nating agents of 98% concentrated sulfuric acid **and** 20-25% fuming sulfuric acid. This simply is not the case. Dai et al. clearly use one or the other.

As argued in Applicants' prior response, moreover (and ignoring the impermissible hindsight basis for the Examiner's contention), even if the proposed mixtures were employed the concentration of fuming sulfuric acid is significantly higher in the sulfonating agent used in the instant claims, resulting in the compounds of structural formula I having, as claimed, a DS in the range of 0.6 to 1.0. This is explained in more detail in the Applicants' specification, at page 6, and is supported by Table 1. For example, the conductivities of the SPPEKs of the invention are significantly superior to the SPPEKs of the reference, as discussed above and supported by Figures 6 and 7. This difference in properties refutes the Examiner's argument in paragraphs 8. and 9. of the previous Action.

#### *Fuel Cell Claims*

In paragraph 10. of the prior Office Action, the Examiner reiterates the rejection of Claims 33 and 34 as being unpatentable over Dai et al., taken in view of Helmer-Metzmann and Hodgdon et al., and with further evidence provided by Larminie et al.; and in paragraph 16 he seeks to rebut Applicants' previous arguments on this issue. The Examiner appears to be asserting that, because Helmer-Metzmann and Hodgdon et al. disclose sulfonated poly(arylene) ether ketones, useful as PEMs, and because the presently claimed SPPEKs fall within that generic group of compounds, it would have been obvious that other compounds within the same generic grouping, specifically the SPPEKs of the reference, would also be useful as membranes in PEMs.

This generalization does not withstand scrutiny, however, and that is particularly true in the case of the presently claimed SPPEKs having a DS of 0.6 to 1.0 and exhibiting

significantly different properties, as evidenced by the higher degree of conductivity and the water insolubility demonstrated, as discussed above. In this regard the Examiner is again invited to review Figures 6 and 7 and Table 1 of the specification.

In paragraph 19. of the previous Office Action, the Examiner concluded: "It would have been obvious to one having ordinary skill in the art at the time the invention was made to have produced a fuel cell with a SPPEK polymer electrolyte membrane... and Hodgdon et al teach that highly thermally stable electrolyte membranes are suitable for fuel cells." As was also discussed above, however, such SPPEKs are water soluble in the claimed DS range of Applicants' defined SPPEKs, and hence are unsuitable for use as membranes in PEMs, and furthermore their conductivity is significantly lower than that of the presently claimed SPPEKs. The conclusions expressed by the Examiner are therefore believed to be manifestly in error.

Form PTO-2038, authorizing a charge in the amount of \$810 in payment of the fee for filing of this RCE, is enclosed herewith.

It is respectfully submitted that all claims of the application, as presently amended, are clearly novel and patentable over the prior art. Passage of the application to allowance is believed to be in order, and is earnestly solicited.

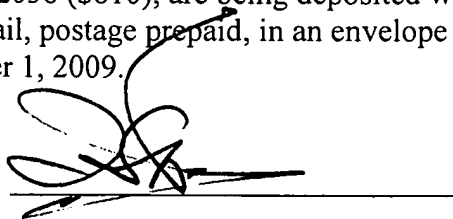
Respectfully submitted,  
YAN GAO, ET AL.

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CERTIFICATE OF MAILING

I, IRA S. DORMAN, hereby certify that this Amendment Accompanying RCE, a Replacement Sheet presenting Fig. 6, and Form PTO-2038 (\$810), are being deposited with the United States Postal Service, as First Class mail, postage prepaid, in an envelope addressed as set forth on the first page hereof, on October 1, 2009.

A handwritten signature in black ink, appearing to read "J. Wayne Anderson", is written over a horizontal line.

cc: J. Wayne Anderson, Esq.